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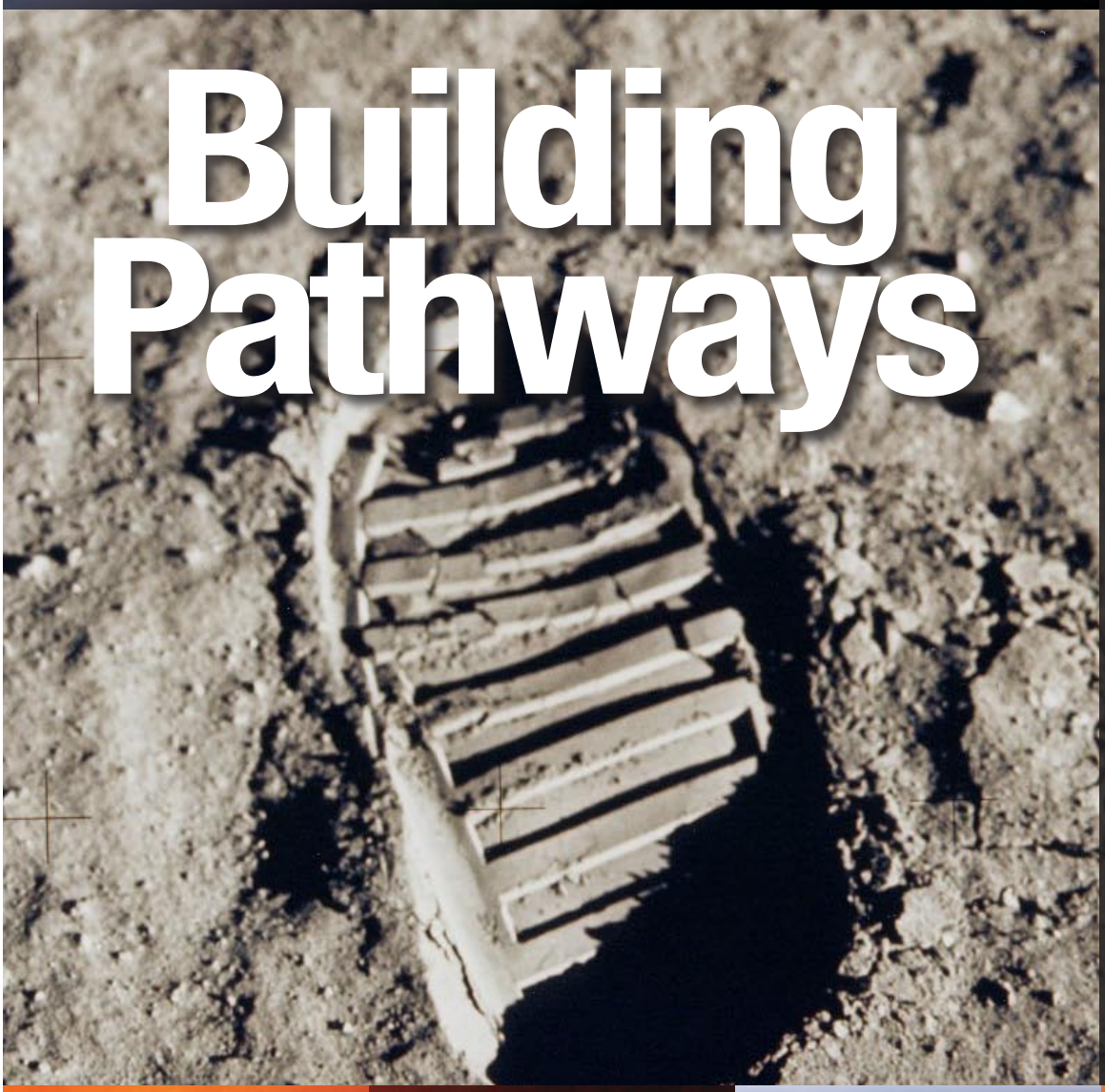
Rendezvous

Where today meets tomorrow



Building Pathways

DATA OWNER: Brandi Dean
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Transition Home | SSPWEB Home | Inside NASA
Web Accessibility and Policy Notices
LAST UPDATED: JANUARY 2009

TRANSITION & Retirement

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PICTURED ABOVE: Buzz Aldrin's footprint in the lunar soil at the Tranquility Base landing site, photographed about one hour into lunar extra vehicular activity on July 20, 1969.

From Leadership

As we approach the planned retirement of the shuttle, we are looking forward toward the future of human spaceflight and exploring beyond low Earth orbit. It is an exciting time and one of some uncertainty. We know that the new administration is considering whether to extend the shuttle program and how to best enable the nation's exploration goals. Whether the shuttle flies for another 18 months or for several more years, the work we do now to prepare for the future is not wasted.

The Space Shuttle Program plays a key role in enabling exploration. Most importantly, the shuttle workforce, after we complete our mission, will transition to supporting the Constellation Program. To help accomplish this critical workforce transformation, each Center has begun significant change management initiatives. At Johnson Space Center, the Space Shuttle Program Office and our Human Resources partners have begun a workforce mapping exercise that will identify the skills of our individual employees, help them define a goal for their role after shuttle retirement, and get them the experience and training needed to reach that goal. It's a big effort, but it is crucial that we preserve the most critical assets that NASA has: the experience and expertise of our uniquely skilled workforce.

We have a challenging task ahead of us. We need to ensure that even as we try to prepare for the future, we maintain our focus on today. Safely flying out the shuttle manifest and supporting the International Space Station is the first step toward enabling exploration. I am confident that we have the team to be successful in both endeavors.

Dorothy Rasco
Manager, Space Shuttle Business Office
SSP T&R Lead
Johnson Space Center

From the Editor

Winter 2009. It seems as if the announcement of the Vision for Space Exploration was only yesterday. Certainly not five years ago. We have a new commander in chief and soon we'll have a new NASA administrator. Major change is in the air! It's exciting, exhilarating and more than a little daunting, too.

In this issue of *Rendezvous*, we've kept our focus firmly on the transition and retirement activities taking place throughout the agency and throughout our centers from coast to coast.

We looked into activities that are designed to help build and preserve skill sets that are needed now for Constellation project development and will be needed even more down the road, on the far side of the gap between the last shuttle mission and the onset of Constellation flight operations.

In *Building Pathways*, we looked into what's going on inside the Focused Investment Groups at Johnson Space Center and how they are collaborating with other NASA centers, industry and academia to develop the breakthrough technology and systems that our future beyond low Earth orbit will require. In *Counting the Links in the Supply Chain*, we examined an area of great concern to the agency and the contracting world as well — preserving the viability of the space program's industrial base through the transition between shuttle and Constellation.

As always, our *T&R Progress Report* touches on some of the ongoing activities across all NASA sites as Constellation elements move from requirements to design, development and testing, and as certain shuttle-dedicated facilities and equipment are decommissioned and, in some cases, repurposed for the Constellation Program. For this issue, our *Moving Forward* column zeroes in on the challenges facing the lunar architecture team as they imagine and design an outpost for living on the surface of the moon. And in *Looking Past Wheels Stop*, Doug McMullen explains how he's actively working to make sure all his folks who man the Safety & Mission Assurance consoles in the Mission Evaluation Room at JSC have career opportunities post-shuttle.

For a while now, we've been wondering just exactly what are shuttle artifacts and who, in fact, decides where they end up. You'll find an interesting discussion based on interviews with experts on both sides of the fence — NASA's Office of Infrastructure and Administration and the Smithsonian Institution's National Air and Space Museum — in *Shuttle Artifacts*.

Finally, we asked our subscribed readership along with past participants from our regular focus and brainstorm sessions to weigh in with their opinions on three timely questions. We think you'll find their comments interesting and provocative, so we encourage you to use the feedback buttons to tell us what you think or comment on anything you read here. And don't forget to subscribe if you haven't already.

We look forward to hearing from you. Enjoy!

Building Pathways

The small, pressurized Lunar Electric Rover at Black Point Lava Flow in Arizona during field testing in 2008.

Giving a FIG about investing in the future.

Michele Brekke has an interesting way of describing the reason for implementing focused investment groups.

"It's skin in the game," Brekke said.

Brekke is Johnson Space Center's Innovative Partnership Office director. Often the "partnerships" part of the title refers to partnerships with the outside world to migrate NASA technology to the general public. In the case of the focused investment groups, however, it's more of a partnership with the future.

Michelle Brekke, Director, Innovative Partnership Office, JSC

"We're investing in product lines, skills and capabilities that are core to our center's mission," she said. "Basically, we're seeding the work that we know is our expertise so we can be ready when the programs come forward and the funding becomes available."

The Advanced Planning Office identified five product line areas that JSC has traditionally invested in and wants to maintain and further develop. And they're putting their money where their mouth is by dividing the Center Director's Discretionary Fund — an amount of money set aside annually for the center director to use as he sees fit — between them. The first one is fairly obvious — Mission Operations, which is Johnson's core competency and always has been. The second FIG is Human Systems, which includes all of the human elements of safe flight, the effects on the human body and the resources needed to keep astronauts alive and healthy over long duration space missions.

The third and fourth FIGs are focused on getting ready for Constellation missions. The Surface Habitat Systems FIG is designing, developing and testing a variety of lunar habitats in cooperation with the Jet Propulsion Lab and Langley Research Center, and the Surface Mobility Systems FIG has already produced the non-pressurized and pressurized versions of a lunar electric rover, which was recently tested at Black Point Lava Flow in Arizona. The fifth competency that the Advanced Planning Office felt compelled to maintain was an area of expertise within the Astromaterials Research and Exploration Science or ARES Directorate. However, the Mission Enabling Science FIG is also a science group, not just a technology development group like the others.

Of course, the concept of NASA investing in technology development is anything but new. But Brekke said the idea behind the FIGs is a little different.

The problem with "popcorn investing"

"In the past, a call would go out to the center and people would write and submit proposals," she said. "We'd receive 30 to 40 proposals from all over and maybe 20 of them would be selected with each getting $100,000 or so. We called it 'popcorn investing.' It wasn't terribly effective because it covered just a year at a time and our scientists and engineers couldn't really put together long-range plans because they couldn't depend on multi-year funding."

Each group gets a larger chunck of money, which they then decide how to spend.

So the FIG concept makes better use of the Center Director's Discretionary Fund by dividing it up among five groups. Each group gets a larger chunk of money, which they then decide how to spend. And perhaps more importantly, they also know they can depend on roughly the same amount of money each year.

"Of course, the FIGs have to come forward every year and report on their progress, just like a program manager's review," Brekke said. "They have to report on how they're investing the money, what successes they've had, what impediments they've encountered, how they expect to use the money the following year and detail their long range plan, and how they see their activities dove-tailing with the program over all."

Serious about future work

According to Brekke, this proactive approach has been quite effective in demonstrating to the line organizations that JSC is serious about future work.

"We're not just waiting around for the programs to come along and then announce that we'll start funding," she explained. "We intend to be prepared. That's skin in the game."

Aside from protecting and sustaining the skills and capabilities that Constellation will need down the road, another purpose of the FIG is to develop the right people. Both the shuttle and space station workforces are relatively mature, due largely to the length of their programs. According to Brekke, the FIGs will also help ensure that JSC is growing the right core competencies and help get "the youngsters" trained up and ready to take over the reins of the new programs as funding kicks in after 2012. Call it skill development in program management.

And though it's a JSC program, JSC won't be the only one to reap the benefits.

And though it's a JSC program, JSC won't be the only one to reap the benefits.

"We're definitely not building empires here, putting up stone walls around JSC so we can gather in all the work on future programs," she said. "We are seeking innovative partnerships with industry and academia. We encourage leveraging the funds allocated to each FIG with industry investments as well. Furthermore, we're actively working with other centers in a collaborative fashion to make sure all the centers have a piece of the pie or a stake in the claim."

Or skin in the game.

Drt. Neal Pellis, Senior Scientist, Space Life Sciences Directorate

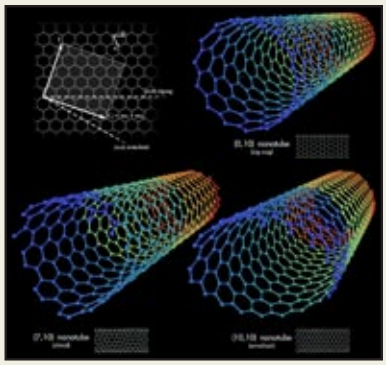
Human Systems: Seeding space medicine

When Neal Pellis, senior scientist in the Space Life Sciences Directorate and lead for the Human Systems FIG, talks, it's easy to get completely lost. Unless you're into biotechnology. The white board in his office at JSC rapidly fills up with arcane molecular biology terms and rough drawings of cells and systems when he explains the primary objective occupying the attentions of his FIG – namely preventive and emergency medical therapies for long duration missions. A broad area, to be sure, but one that is defined and limited by the environment of space.

For instance, remember the scene in *Cast Away* where Tom Hanks' character bangs out a bad tooth with a stone? That wouldn't be any less painful using a moon rock. To avoid that scenario, a partnership between engineering at JSC and the bioscience community, including a private company and a university, has developed a methodology for sterilizing and stabilizing a damaged tooth, non-invasively, with a device no larger than a pack of playing cards. The device hardens a type of polymer that can be applied like dental amalgam. It may be just a tooth, but an abcessed tooth, left untreated, can cause a ripple effect of infections that can lead to death in just a matter of days, and you can't make a quick trip to the dentist if you're living on the moon or on your way to Mars.

Somewhat more abstract is the FIG's study of carbon nanotubes. Pellis and his team are looking at their potential in combating the effects of space radiation by using them to scavenge free radials in the human system. Tissue morphogenesis, or building tissue from individual cells in a microgravity environment, is another area of focus for his team. They're also concerned with the effects of space dust — not so much how it affects the equipment, but how toxic it could be to the human system. So, applying innovative chemical scanning methods, they're developing highly accurate systems that monitor for space dust contamination.

What is important to note is that, although the success of the Human Systems FIG is largely dependent on the participation of academia and private enterprise with vested interests in emerging technologies, the results promise to deliver wide-ranging benefits in Earth-bound healthcare as well.



3-D models of three types of single-walled carbon nanotubes.

... the results promise to deliver wide-ranging benefits in Earth-bound healthcare as well.

Kriss Kennedy LSS-Altair Integration Lead, LSS Habitation Manager, SHS FIG Project Manager Lunar Surface Systems Project Office / Systems Architecture & Integration Office

Surface Habitat Systems: Taking shape in Hangar X

Kriss Kennedy, the lead for the Surface Habitat Systems FIG, is a bonafide space architect and has been working on surface habitats for more than 21 years. Not only does he have a deep-seated understanding of the technology issues inherent to designing and developing Earth-bound habitation systems that must operate flawlessly on the lunar surface, but he also knows where the gaps are.

"When I say 'gaps,' I mean, technology-wise," Kennedy said. "What's not being funded and what's not being worked on."

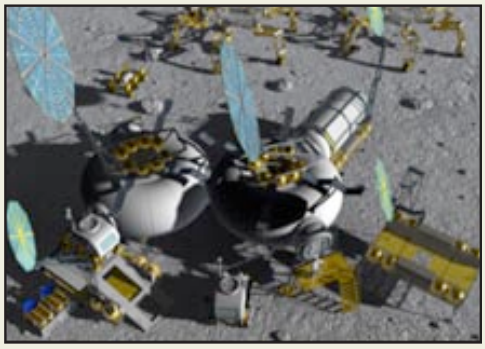
There's been a progression of surface habitat scenarios looked at over the last couple of years — the activities of the Lunar Architecture Team evolved into the Constellation Architecture Team in 2008, which focused on three different lunar scenarios. And as the team continues to mature and consider different ways to set up an outpost to facilitate lunar explorations, they keep coming up with new ideas and designs. They're up to eight now.

... as the team continues to mature and consider different ways to set up an outpost to facilitate lunar explorations, they keep coming up with new ideas and designs.

But the primary focus of the FIG and taking shape right now in Hangar X at Johnson Space Center are two basic strategies or approaches to lunar surface structures — an inflatable concept and a hardshell concept — both of which consist of a core habitat and a reusable logistics module that attaches to it.

"We selected several projects and development areas that were not being worked on to fund," Kennedy explained. "We built some of the initial aspects of the Three-Meter Module. We funded inflatable habitat hatch integration work and the habitat test bed development."

The work on the bench top test bed is actually occurring in a corner of JSC's Hangar X, where a group of habitat test bed leads are building a test bed that will link the software management system of the habitat with the actual hardware.



An artist's depiction of a lunar habitat.

"We focused on three main areas last year in the Surface Habitat System FIG: concept development and validation, the test bed, and inflatable habitats," Kennedy recapped. "But for this year, we created a steering committee from other directorates and from among our customers and stakeholders, to discuss the direction of our work and decide what's working and what isn't."

In all, the FIG has chosen seven projects from those four areas and has begun collaborating with other centers and research facilities including White Sands, Langley, Kennedy, Marshall and Ames.

It's not like we're off on an island doing this by ourselves," he said. "We're strongly integrated ... and actively trying to leverage and share."

Rob Ambrose, Deputy Division Chief for Automation, Robotics and Simulation Division Exploration Technology Development Program

Surface Mobility Systems: Just rolling along

Those of us who remember the Apollo era and the dunebuggy that went for a short spin on the lunar surface assume that getting around on the moon shouldn't be that much of a problem. We've done it before, so how much of a challenge could it be?

But given the far more ambitious nature of the Constellation Program's lunar missions, the challenges are enormous. And really interesting, too.

Rob Ambrose, lead for JSC's Surface Mobility Systems FIG understands the problems quite well.

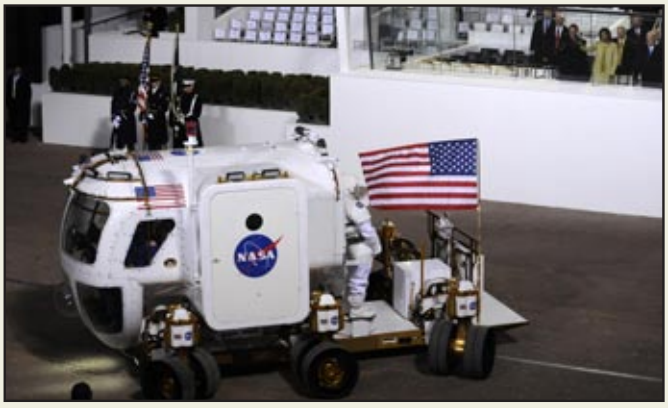
"First of all, if you look at lunar rovers with seats, like the ones they used during Apollo, there are a number of problems with just stabilizing the space suit," he explained. "When they're pressurized, they don't bend very well."

So he and his team came up with a novel approach, the astronaut upright, as if standing up in a chariot. That was his FIG's first project in 2008 — the design, development and testing of the new crew accommodation for unpressurized rovers. In other words, an open chariot-like lunar rover that could be driven from a standing position to accommodate the limitations of pressurized spacesuits.

The second project that benefitted from FIG funds was the development of a next generation drive train that would step up the performance of a lunar mobility system and allow a rover to move about at two speeds — a low gear for extreme terrain and for workhorse activities such as bulldozing and other high torque applications, and a second gear for cruising along at 20 kilometers per hour, more than fast enough for the undeveloped lunar surface.

Then they started looking at different configurations for the vehicle and decided to put a small pressurized cabin on the rover base, which would be more appropriate for longer duration missions on the lunar surface. Built at JSC through collaboration between four divisions — Automation, Robotics and Simulation; Habitability and Environment Factors; Human Adaptation and Countermeasures; and Thermal Systems— the Lunar Electric Rover, or LER, rolled out of JSC's Building 9 on Sept. 2. The very next month, the rover was put through its paces at Black Point Lava Flow in Arizona. Then, on Jan. 20, it was introduced to the nation in the Inauguration Day parade in Washington, D.C.

Astronauts and geologists put the Lunar Electric Rover to the test during the Desert Research and Technology Studies conducted at Black Point Lava Flow.



The Lunar Electric Rover struts its stuff for the new President and Mrs. Obama during the Inaugural parade on Jan. 20.

According to Ambrose, those projects were his FIG's technology goals for 2008 and working through those design, development and testing phases provides great experience for the younger team members. For 2009, his projects will include optimizing the rover with tools and new sensors, making modifications to the chassis, looking at weight reduction and improving the vehicle's performance of its drive, steering and suspension. That should be enough to keep them busy this year, and there are plenty of other areas left to explore in coming years.

"We think of a crew mobility system as self-contained spacecraft. It's just rolling rather than flying."

"We think of a crew mobility system as self-contained spacecraft. It's just rolling rather than flying," Ambrose said. "So the work we do really goes to a number of core space vehicle disciplines and domains that will be essential for the lunar program."

And while all this is going on, in addition to building the next generation of lunar rover, Ambrose's team is also helping to build the next generation of lunar rover engineers.

"A meta-objective that I had for the projects was to also educate my young engineers on core rover subsystems," Ambrose explained. "Some day they'll be the system managers for these machines."

Lisa Fletcher, branch chief for Center Operations Directorate

Mission Enabling Science: Fine-tuning for future missions

The Mission Enabling Science FIG works on scientific and technology developments to help enable future moon and Mars exploration. According to Lisa Fletcher*, former lead of the FIG within the Astromaterials Research and Science Directorate, they focus on scientific proof of concept for bench top instruments for certain mission objectives. They then work with the engineers to make these instruments smaller or use less power. In short, anything that is required to make them flight ready.

Another key focus of her FIG was data integration and analysis.

"So much data is sent back from these missions," Fletcher said. "Our ARES scientists take that data, do the interpretation and then turn it into science and mission requirements for future missions."

"Our ARES scientists take that data, do the interpretation and then turn it into science and mission requirements for future missions."

For 2008, the Mission Enabling Science FIG worked four projects: 1) Characterizing the physical and chemical properties of lunar soil particles (moon dust); 2) Building a prototype reactor for oxygen production on the moon; 3) Developing a prototype fiber optic surface sensor for micro-meteoroid impacts, and; 4) Building, in collaboration with the Los Alamos National Lab, a lunar-bound replica of a Laser Induced Breakdown Spectroscopy — or LIBS — instrument that was initially developed for the next Mars mission.

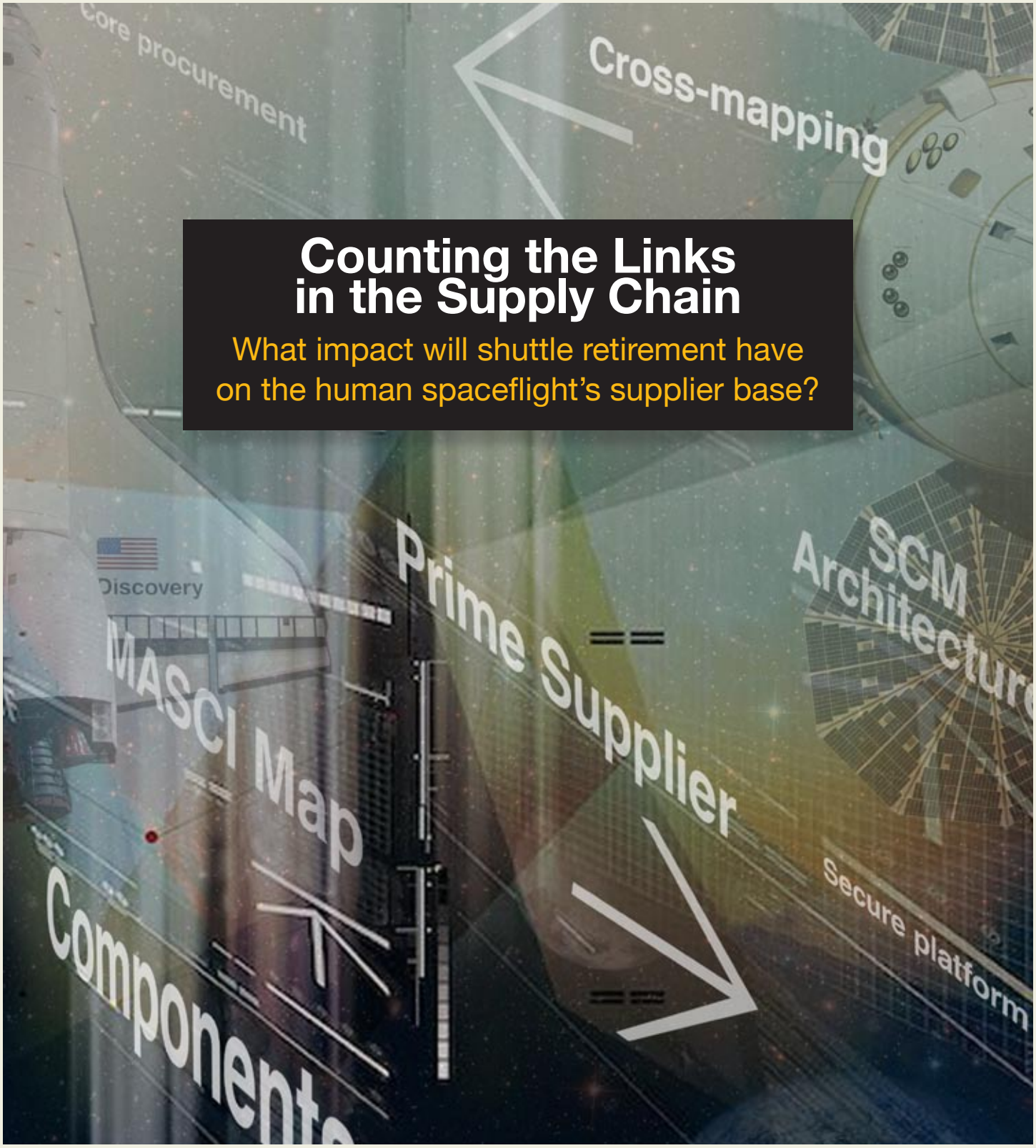
Fletcher explained that the lunar soil study, one of four projects on moon dust, was set up specifically to study the really small particles, less than 20 microns in size, in order to understand how to better protect the astronauts and sensitive moon-based equipment. The oxygen reactor was developed as a bench top device that used cyano-bacteria to produce oxygen as a byproduct in the lunar environment. Both of these projects were completed in 2008.

An artist's depiction of the LIBS in action on Mars.

In addition to the fiber optic surface sensor project and the LIBS instrument project, the Mission Enabling Science FIG is currently focusing on two more projects for fiscal year 2009 in preparation for future lunar missions. They are developing a prototype forward-looking infrared camera from off-the-shelf components to be used as a lunar geology field tool. And they are working on integrating a 3-D software package with thermal, mineralogical and terrain data to facilitate site selection requirements for future lunar missions.

Getting there safely is one thing, but having the data necessary to select a safe site for landing and building a lunar outpost will be pivotal to the success of these missions.

**Lisa Fletcher is now branch chief for the Center Operations Directorate.*



Counting the Links in the Supply Chain

What impact will shuttle retirement have on the human spaceflight's supplier base?

Rendezvous interviewed Mike Galluzzi, NASA's supply chain management cross-cutting lead for Transition, and Ted Bujewski of The Aerospace Corporation, industrial base lead for the Exploration Systems Missions Directorate Transition team, to get the download on the challenges they're facing as the shuttle program comes to an end and the Constellation Program ramps up.

When the shuttle retires, there's a real possibility that some of its parts suppliers may retire, too. After all, there are only three orbiters and once they're grounded for good, the need for critical spares will go away. In the years between the retirement of the shuttle and the beginning of flight operations for Constellation, how will the space program's industrial supply base survive? And what will happen when Constellation needs parts, subsystems and critical spares but many of the qualified suppliers of space hardware are long gone? Imagine the cost of building a new supply base.

That's where Supply Chain Management comes in.

Supply Chain Management, or SCM, is a complicated area of expertise in any industry. In manufacturing for automotive or commercial aerospace, for example, the myriad components, elements, systems and spares that come together just in time for a car or a plane to roll off the end of an assembly line represent massive procurement, inventory and distribution systems.

In human space flight, SCM becomes a different kind of animal. No less complex, certainly, but defined by different parameters that spring from the very nature of the space program. Orbiters, space stations and other man-rated spacecraft aren't products of assembly lines. They are not manufactured in quantity. The frequency of their missions is extremely low, and their architecture and configuration are incredibly complex.

From left to right: Michael Galluzzi (seated) and Ted Bujewski (standing)

Addressing misconceptions

According to Galluzzi, a common misconception about SCM is that it is, in effect, a commercial business model that only focuses on managing suppliers. Galluzzi rejects this notion. Instead, he believes that SCM is an evolved logistics philosophy that enables both NASA project elements and prime contractors to reduce non-recurring operations and sustainment cost impacts, while improving hardware availability throughout the life of a program. But managing suppliers is only part of the equation. He also maintains that when properly implementing SCM principles, insertion of new technology becomes a part of the process rather than the exception. This allows for a more robust level of technology readiness that, in turn, shapes product demand.

… a common misconception about SCM is that it is, in effect, a commercial business model that only focuses on managing suppliers.

"When I refer to the life of the program, I mean from the very start — from design, development, test and evaluation – or DDT&E – to validation, to production, and all the way to systems termination and disposition," Galluzzi explained. "This is because SCM architecture is designed with product lifecycle management as its main focus, which requires integration of program functions from start to finish. In short, SCM is a critical part of the design process. At the end of the day, approximately 80 percent of recurring operations costs is influenced during DDT&E."

A clear case in point here is the historical cost of shuttle operations — a result of initial design and development that focused primarily on extraordinary performance parameters, and not as much on an extended life of processing operations, design standardization and project collaboration.

An "-ility-centric" philosophy

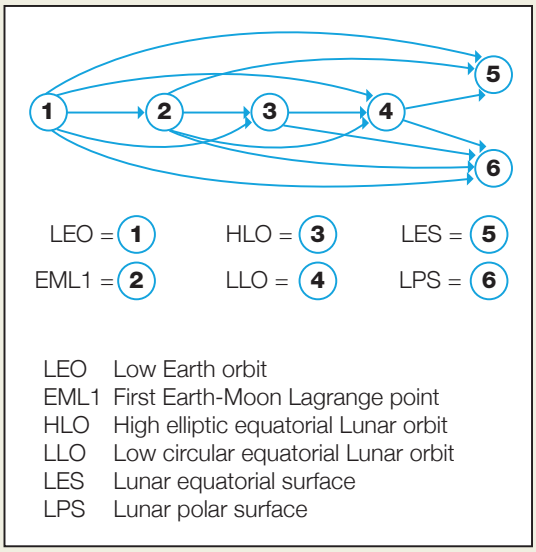
"SCM has a philosophy that is focused on agile operations and flexible manufacturing, just-in-time production and vendor-managed inventories at strategic locations called logistic nodal points," Galluzzi explained. "It's what I call '-ility-centric' — sustainability, reliability, maintainability and affordability, which leaves the program with the ultimate '-ility' — accountability."

"It's what I call '-ility-centric' – sustainability, reliability, maintainability and affordability which leaves the program with the ultimate '-ility' – accountability."

Agile operations are then able to meet program requirements without adding significant funding requirements. But in space, logistic nodal points and spares programs take on entirely new meanings. They become interplanetary.

"As we leave low Earth orbit, we won't have much up-mass flexibility, and when we start lunar base operations, we're not talking about a week-long camping trip any more," Galluzzi explained, in a reference to the Apollo lunar missions of almost 40 years ago.

As we move into lunar and Mars objectives, the supply chain movement of materials, people and information from Earth-based sources to interplanetary destinations becomes highly complex. Any slip in schedule due to unavailability of parts, spares or hardware components becomes exponentially more expensive and increasingly risky as the supply chain increases in distance and complexity.



An Earth-Moon Transportation Network example as represented in "Concurrent Trajectory and Vehicle Optimization: A Case Study of Earth-Moon Supply Chain Logistics," an A.I.A.A. paper presented by Christine Taylor and Olivier deWeck, M.I.T.

Much more than stocking the shelves

Bujewski explained that up until now, there have been two standard approaches to managing operations and sustainment within NASA — neither of which are known to be as agile or lean as SCM, nor as adaptable to financial and political pressures or flight manifest changes.

The first approach is Integrated Logistics Support, or ILS, which was implemented by the U.S. Army in the early 1970s and served, for the most part, as the foundation for shuttle logistics. This paradigm focuses on stocking the shelves with inventory based on such metrics as mean time between failure, mean time to repair, probability of sufficiency and repair generation rate forecasts, among other things. However, a problem with this approach is that in a dynamic engineering environment that realizes frequent design changes, chances are good that there will be some obsolete inventory on the shelves.

The second approach is a more evolved ILS process known as Performance-Based Logistics, or PBL. It relies on the prime contractor to support operations and sustainment on a fixed-cost basis. PBL was introduced around 1994, at roughly the same time that the Commercial Off-The-Shelf or COTS initiative was introduced at the Department of Defense. Today, without the proper contract language in place, this approach is also dated. But more importantly, it offers limited government oversight.

PBL's weaknesses are well documented in a 2006 GAO report entitled: "Space Acquisitions: DoD Needs to Take More Action to Address Unrealistic Initial Cost Estimates of Space Systems." The report details specific areas in which program officials were overly optimistic in their assumptions — most notably in that the industrial base would remain constant and available.

"What may be missing in the PBL paradigm is the requirement for a cross-element and cross-program information-sharing environment," Galluzzi said. "That would provide transparency to the programs so they could understand the demand pressures and other influences on the liquidity and profitability of the space industrial base."

To further complicate the issue, the key to it all hinges on the SCM architecture, which integrates a lot of different information sources. According to Galluzzi, this encompasses a rather wide variety of software applications including shared master data files, CAD systems, materials requirements planning and supplier relationship management applications. The latter focuses on managing supplier and product line viability and other variables that can negatively impact a healthy supply base. [Editor's Note: Confused, yet? Galluzzi and Bujewski were just getting warmed up!]

Changing requirements between programs

Now imagine SCM from a transition perspective where the focus has to be on what the changing requirements are from both shuttle and Constellation, and also on cross-mapping all those suppliers. Understanding what supplier supports which subsystem, as well as the relationships between them, will help quantify risks during the gap between programs. After all, a problem with one supplier can have unforeseen repercussions throughout an element or program..

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For instance, what happens if, because of the low level of demand for a part, the supplier no longer has the tooling or the expertise to manufacture that part that's needed for shuttle or Constellation? Or the business case to support NASA contracts no longer makes financial sense five years later? It's an expensive and time-consuming problem.

"NASA is only 4 percent of the aerospace industry and approximately 30 percent of the domestic space market," Galluzzi said. "So when you compare the $8 billion or so of appropriated funds for human space flight to the aggregate $200 billion in aerospace industry revenue, you realize that NASA really has very little influence over the major supplier's profitability on space products."

The bottom line is that suppliers may not be going out of business so much as realizing little or no profit margin in manufacturing NASA space-qualified hardware.

Applicability to NASA

As the crosscutting SCM lead to transition, Galluzzi routinely hears two comments that he believes are false. First, that SCM does not apply to NASA and its space systems. And second, that the prime contractors supporting the projects are responsible for material shortages and industrial base management, so there is no need for NASA to manage the supply chain.

"SCM is a true end-to-end process," Galluzzi stated. "But more importantly, it's a means of reducing the indirect core procurement activity costs that are associated with operability and sustainment. So I can't think of a better industry where SCM does apply."

The fact is: SCM enables the optimization of cost efficiencies and hardware availability for the life of a program for both NASA project elements and prime contractors.

"We have such low flight rates and low product demand," he explained. "All the more reason to understand how to shape product demand while being closely engaged with our projects."

Cascading impacts

It's important that components are delivered on time, every time, because if a delivery of a part that's critical for launch is missed, then the launch is delayed.

That's bad enough for shuttle missions, where delays add up rapidly in terms of schedule and financial costs. Scrubbed launches mean pushing mission schedules back not just a day or two, but sometimes months —which, in turn, impact how the International Space Station is provisioned and re-crewed, not to mention constructed. Leaving low Earth orbit can only make it more complicated.

"If there's someone on the moon waiting for a shipment from earth and we've got a glitch, how do we ensure we get it to the moon on time?" Bujewski wondered.

… if a delivery of a part that's critical for launch is missed, then the launch is delayed.

Making progress

Galluzzi and Bujewski, in addition to other contractor participants in the Innovative Partners Program, have been working diligently through 2008 to develop software tools and other initiatives that will assist the agency in preserving and protecting the industrial base. Among SCM initiatives that include several studies and efforts to build relationships across a number of government agencies, two software tools and the establishment of a space commerce network are particularly noteworthy.

First, **Prime Supplier™** (patent pending), developed by Galluzzi, is a tool that uses programmatic data and other influences on the liquidity of single source suppliers to determine a supplier's economic stability and better understand demand pressures on their product line. Specifically, it was developed to manage diminishing manufacturing sources and material shortages and identify areas for potential pooling of non-recurring program funds required for obsolescence mitigation. Prime Supplier successfully identified cross-program capabilities and showed potential supplier contract gaps between the shuttle program and Constellation. To date, six Fortune 500 companies have expressed strong interest in licensing this emerging technology.

MASCI Map, a supplier mapping software application initially designed for the Missile Defense Agency, was acquired for the purpose of identifying cross-element and cross-program utility and impacts. The application provides:

- a geographic and tabular view of the programs' supplier base
- a visual representation of supplier relationships based on program and element information from a NASA database
- congressional district mapping
- supplier demographics
- supplier customer diversification
- and natural disaster visualization.

In short, MASCI Map provides the agency with an SCM big picture.

Finally, the implementation of a Space Commerce Network known as Network Centric Manufacturing or "**Supplier City**," could conceivably provide an opportunity to 'rescue' resources in danger of being terminated. In effect, Supplier City would be an interagency collaboration between NASA's Exploration Systems Mission Directorate, the Office of the Under Secretary of Defense for Acquisition and Logistics, Missile Defense Agency, and other third-party system integrators. It is envisioned to be a solution to potential national security threats associated with industrial base and skills loss through attrition and product obsolescence. The end result would be deployed at various locations throughout the country, with the NASA Shuttle Logistics Depot on Florida's Space Coast as a potential pilot site.

Mandated from the top

Even given everything Galluzzi and Bujewski have accomplished thus far, some still ask the question why not just let the prime contractors worry about SCM and the viability of the industrial base?

The answer is simple: It's a presidential directive.

... some still ask the question why not just let the prime contractors worry about SCM ...

President Bush issued National Space Policy Directive 49 on Aug. 31, 2006. In it, an overarching national policy that governs the conduct of United States space activities was established. It includes specific language regarding the agency's responsibility for maintaining the country's space-related science, technology and industrial base.

"A robust science, technology, and industrial base is critical for U.S. space capabilities. Department and agencies shall: encourage new discoveries in space science and new applications of technology; and enable future space systems to achieve new and improved capabilities, including incentives for high-risk/high-payoff and transformational space capabilities. Additionally, departments and agencies shall: conduct the basic and applied research that increases capability and decreases cost; encourage an innovative commercial space sector, including the use of prize competitions; *and ensure the availability of space-related industrial capabilities in support of critical governmental functions."*

For Galluzzi, Bujewski and their space counterparts across government, those last 15 words are their marching orders.

T&R Progress Report

Activities across NASA

The Common Extensible Cryogenics Engine during its recent test at the Pratt & Whitney Rocketdyne facility in West Palm Beach, Fla.

"Transition" has become the operative word these days around NASA. While retirement looms large for the space shuttle in 18 months or so, the buzz of activity surrounding Constellation grows louder each month. Project elements have moved from design into development, testing and evaluation. Firing rooms are being unveiled. Engines tested. Pivotal contracts awarded. Milestones met.

Ares I-X Comes Together

It took two days and 12 tractor-trailer rigs to transport the 11 steel cylinders that make up the Ares I-X upper stage simulator from Glenn Research Center in Cleveland to Wellsville, Ohio, where they were loaded into the Delta Mariner for transport over river and ocean to Kennedy Space Center. Each massive steel segment is 18 feet in diameter, almost 10 feet tall and weighs between 24,000 and 60,000 pounds. While in transit, each segment was monitored with data loggers to measure temperature, humidity and atmospheric pressure.

Currently being assembled in the Vehicle Assembly Building at KSC, the segments were fabricated from bridge-construction strength steel. The total weight of the assembled upper stage of the rocket will accurately simulate the weight of a fully fueled upper stage. Only the first four segments of the first stage will be active for the Ares I-X test, scheduled for summer 2009. The fifth segment will consist of an upper stage and a sensor-laden Orion mass simulator.

The Orion mass simulator and an associated launch abort tower are the products of a matrixed team representing various organizations including NASA's Ares I-X crew module/launch abort system project, an off-site contractor working on fabrication and assembly and a separate sensor installation team. All are working in tandem to produce the full-scale simulated Orion module and launch abort tower to the precise specifications needed to accurately mimic the shape and physical properties of the models used in computer analyses and wind tunnel tests at Langley Research Center. Actual flight test results will be compared with preflight predictions based on these models. This last two-part piece of the Ares I-X test article is scheduled for delivery to KSC early this year to be mated with the segments from Glenn.

The test launch, the first test of a new launch vehicle for human spaceflight since 1981, will measure in detail how a single booster with a large stage mounted on top of it will perform as it leaves the pad and ascends into the upper atmosphere. This first test of the Ares I-X is scheduled to lift off from Kennedy Space Center this summer. It will climb about 25 miles in a 2-minute powered flight, continuously measuring vehicle aerodynamics and controls and first-stage performance. It will culminate in a test of first-stage separation and the parachute recovery system. According to Jonathan Cruz, deputy project manager for the Ares I-X crew module/launch abort system, the team needs those two minutes of flight data before it can continue to the next phase of rocket development.

The data will be used to support the vehicle's critical design review in 2010.

Left: The Crew Module and Launch Abort System in the stacked configuration.

Right: The Ares I-X Launch Abort System simulator is backed into a NASA Langley hangar. Two extra long flatbed trucks will be rolled into a C-5 transport aircraft for the trip to Kennedy.

Orion Passes Another Test

When it comes to Orion, the folks at Dryden Flight Research Center get to do the really cool stuff – or so it seems to the distant bystander.

In preparation for this spring's scheduled launch abort system flight tests at White Sands Test Facility in New Mexico, engineers at Dryden completed mass property tests on the Orion boilerplate crew module in late October. The tests, which included weight and balance testing as well as moment-of-inertia testing, will help the system's engineers accurately predict how the crew module will behave during the upcoming tests.

The weight and balance tests determined how the test module's weight is distributed by taking measurements at three points with the module tilted at various angles. The moment-of-inertia tests, conducted in Dryden's Flight Loads Lab, measured the module's resistance to rotation by forcing small rotations and then precisely measuring the resulting motion.

The boilerplate Orion crew module that will be used for the Orion Launch Abort System Pad Abort-1 flight test is tilted on jacks during weight and balance testinng at Dryden.

Balancing a Pencil

To many of the engineers working at Langley Research Center, the transonic dynamics wind tunnel they're using to determine Ares I-X's stability in high winds has a deep connection to the Apollo era of spaceflight. In fact, 40 years ago, the same wind tunnel was used to test the Saturn V rockets. So when it came time to start the series of ground test wind loads on the Ares I-X, the Langley testing team contacted some Apollo testing veterans to learn just how they did it.

Getting the rocket to the pad has been compared to "balancing a pencil." The Ares I-X measures 325 feet from top to bottom, but has a first stage diameter of only 13 feet. According to design analysts, Ares I-X will stay upright in a 47-knot wind, fastened in four places at the rocket's base, while moving a little less than one mile per hour on a crawler transporter between hangar and launch pad. While at the pad, additional bracing will enable it to withstand a 65-knot wind.

However, bracing is not used during a launch, and without bracing, the Ares I-X could sway as much as 8 feet at the tip. This would be a problem since launch workers have to vacate the platform if the rocket sways more than 3 inches. Any more oscillation than that and the work platforms have to be withdrawn, too, to keep the rocket from bumping against them.

So Langley engineers spun up the transonic dynamic tunnel and conducted a series of scale model tests on both the rocket and a simulated launch tower to help define what the constraints are and what viable launch conditions might be. The data they generate will be used to analyze the vehicle and for developing computational flow models to predict the rocket's behavior in windy conditions. The multi-step tests will determine which way the rocket will sway in what wind speed and direction.

Langley engineer Tom Ivanco inspects part of the simulated launch tower between scale model tests of NASA's Ares I-X rocket in the Langley Transonic Dynamics Tunnel.

The LAS abort motor test firing.

More Smoke 'n Fire

Launch abort motor tests wrapped up in late November with a successful 5.5-second ground test firing at the Alliant Techsystem – or ATK – facility, in Promontory, Utah. The test was the final in a series of motor and component tests conducted earlier this year as a run up to the next major milestone scheduled for this spring. The abort motor, measuring 17 feet tall and 3 feet in diameter, was fixed in a vertical test stand with its four exhaust nozzles pointing skyward. During the test, flames shot more than 100 feet into the air.

The launch abort motor provides a half-million pounds of thrust to pull the crew module away in the event of an emergency on the launch pad, or during the first 300,000 feet of ascent. Although launch abort motors were used during the Apollo program for the same purpose, the Orion abort motor employs latter-day technology and more robust design and materials, such as a composite case and an exhaust turn-flow technology, which delivers weight savings and improved performance.

Firing Room Revelation

A key difference between the shuttle program and the Constellation Program is obvious when you look at the two Launch Control Centers. In the shuttle's firing room, 200 engineers sit elbow to elbow at consoles so close together, there's barely space to turn around. In the Ares I-X firing room, there's a set of consoles arranged in a horseshoe shape in the middle of the room with a couple of rows of consoles on risers around it.

Because it will be a test of the first stage, the Ares I-X test flight will only require 26 controllers. The rest of the stack will not be active – the upper stage and Orion crew module at the top of the stack will be simulators for the test. For an operational Ares I mission, the number of controllers needed would grow to 100 or so.

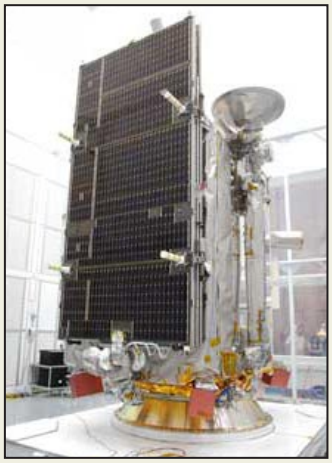
While building the room, the launch control team zeroed in on "leaning out" the requirements for the launch support team. Because it's the first new program for NASA in more than 30 years, they now have the chance to integrate the latest technologies and procedures — all information will be electronic instead of in the form of thousands of pages of procedures as is the case with shuttle launches. Countdown will be a completely paperless system.

Firing Room 1 in the Launch Control Center will also be used for future Ares I flight tests, operational Ares I and Orion launches.

Preparing for Lunar Extremes

The Lunar Reconnaissance Orbiter has already been subjected to extremes and came through with flying colors. Simulating the extreme temperatures and vacuum of space, thermal vacuum testing conducted at Goddard Space Flight Center in Greenbelt, Md., wrapped up the orbiter's environmental test program in late December. Carrying seven instruments to provide Earth-bound scientists with maps of the lunar surface and gather information on the moon's topography, lighting conditions, mineralogical composition and natural resources, the data will be used to select safe landing sites and future sites for lunar outposts. The orbiter will spend at least a year in a low, polar orbit approximately 30 miles above the lunar surface while its instruments do their job.

According to Dave Everett, the mission's system engineer at Goddard, the thermal vacuum testing team "cooked it, froze it, shook it and blasted it with electromagnetic waves" and it still worked. Of the 2,500 hours of powered testing conducted throughout last year, more than 600 hours were thermal vacuum testing.



The LRO spacecraft in the Goddard Space Fight Center cleanroom.

Sending Up Supplies

How will we re-provision the International Space Station once the shuttle is retired? The Russians' Soyuz vehicles can ferry crew and their Progress vehicle can handle small payloads.

To handle cargo delivery services to the space station using a United States commercial carrier, NASA recently awarded two Commercial Resupply Services contracts to Orbital Sciences Corporation of Dulles, Va., and Space Exploration Technologies of Hawthorne, Calif. The contracts each call for the delivery of a minimum of 20 tons of upmass cargo the space station, as well as delivery of non-standard services in support of cargo resupply. The contracts, which began Jan. 1, are effective through Dec. 31, 2016, and are fixed-price, indefinite delivery and indefinite quantity. NASA has established production milestones and reviews on the contracts to monitor progress toward providing services.

Happy Landings

How do you land on the moon? Slowly and softly. And, according to recently completed tests at Pratt & Whitney Rocketdyne in West Palm Beach, Fla., with a really cold motor. The Common Extensible Cyrogenic Engine — or CECE — uses extremely cold liquid oxygen and liquid hydrogen as propellants to generate its 13,800 pounds of thrust. But CECE is also a deep-throttling engine, with the flexibility to reduce its thrust from 100 percent all the way down to 10 percent, which is what you need to land on the surface of the moon without a jolt.

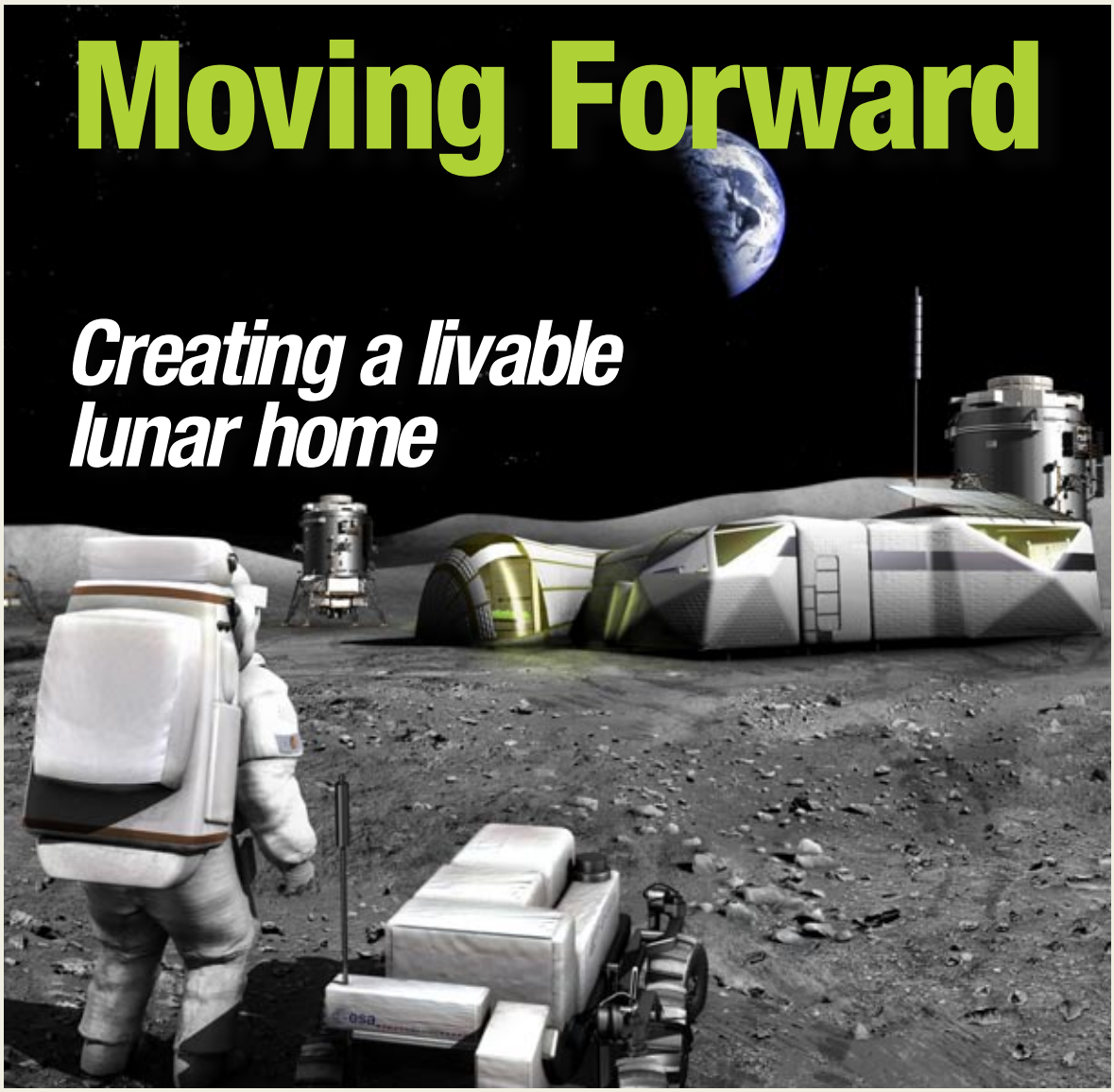
During this last test, the CECE was throttled down from a high of 104 percent to 8 percent — a record. In the first two tests in 2006 and 2007, low-power-level throttling and engine characteristics were carefully examined. This third set of testing was intended to resolve some of the challenges that cropped up as a result of the early testing. For example, an earlier test showed evidence of "chugging," a condition in which pressure oscillations occur in the engine at lower throttle levels that could result in vibrations in the structure of the rocket. Not a good thing for the lander or the crew.

In this last test series, the latest engine configuration incorporated a new injector design and propellant feed system that managed the pressure, temperature and flow of propellants, thus eliminating the dreaded "chugging."

The CECE design is based on an existing Pratt & Whitney Rockedyne RL 10 upper stage rocket engine. The CECE collaboration includes engineers from NASA's Marshall Space Flight Center and Glenn Research Center, as well as Pratt & Whitney Rocketdyne.

Moving Forward

Creating a livable lunar home



An artist's depiction of a moonbase.
(Credit ESA-AOES Medialab)

"… We leave as we came and, God willing, as we shall return – with peace and hope for all mankind."

- Eugene A. Cernan, Apollo 17 Commander, December 14, 1972

As the Constellation Program continues to develop, getting to the moon is only one piece of the puzzle. NASA's Lunar Architecture Team is developing the systems and processes to make sure that once we get there, we can stay a while.

Taking the next step

Almost 40 years ago, the first American stepped on the moon and left an indelible imprint, not only on the lunar surface, but also on the imagination of an entire generation. Now that same generation, inspired so many years ago, is taking the next step.

NASA plans to establish a human outpost on the moon through a series of lunar missions slated to begin in 2020. With that goal in mind, NASA's Lunar Surface Systems Office was formed in September of 2007 and tasked with the development of the systems and capabilities necessary to sustain extended stays on the lunar surface. The office is still in the early stages of the process, but work is already well under way.

"We're not trying to define the end point or the baseline as of yet," said Chris Culbert, Lunar Surface Systems Project Office manager. "We're really trying to get our arms around the breadth of the opportunity. What kind of things could you do? What combinations of things make more sense? How do they trade against each other? Which characteristics emerge as better ideas? We are not going deep, we are going broad."

... the team of engineers is working with commercial and international partners to define what exactly sustaining life on the moon means ...

Still two to three years away from the requirements process, the team of engineers is working with commercial and international partners to define what exactly sustaining life on the moon means, and conceptualize and compare ideas for what it will look like.

"The partner contributions will be just as substantial and, hopefully, comparable in time and scope to the things we might have in mind," Culbert said. "So, part of what we are doing is creating this architecture and defining various ways of putting together an outpost on the moon."

This requires engaging in discussions with partners to determine their interests, priorities and objectives, as well as understanding the science community's needs and how they would utilize the surface infrastructure to meet their interests. Out of all that, they will coalesce some kind of well-defined infrastructure that makes sense to everybody and meets the broadest range of needs.

With so many potential parties represented, ideas abound about exactly what the lunar structure should look like and how it should function.

"As consensus emerges, hopefully everybody will get at least some of what they want," Culbert said.

An artist's rendering of a lunar outpost.

Living off the land

With the Vision for Space Exploration came an unspoken series of goals for lunar architecture. Returning to the moon and eventually moving on to Mars means developing the capabilities to sustain human life for large portions of time away from Mother Earth.

"Long-term human presence throughout the solar system requires us to solve a variety of technical issues that we don't have a lot of experience with right now," Culbert said.

While the Apollo missions taught us a lot, there is still much left to learn — taking into consideration the fact that all our lunar surface experience comes from the equatorial regions. While the moon is a fairly homogeneous environment, the Polar Regions, where future lunar habitats will most likely be established, present many unique challenges.

A large part of sustaining life for long periods of time – on the moon or anywhere – means learning how to make use of the environment around you. Some of the early work in lunar architecture is concerned with taking advantage of what the moon has to offer.

With that in mind, the Lunar Reconnaissance Orbiter (LRO) is scheduled to launch this spring. It will be the first mission of NASA's Vision for Space Exploration, and one of its primary objectives is determining the resources present on the moon that can be utilized. It will also search for safe landing sites, characterize the radiation environment and demonstrate new technology.

... one of its primary objectives is determining the resources present on the moon that can be utilized.

"That's a biggie to us," Culbert said. "The amount of data we get off the moon from LRO alone will be of a magnitude greater than anything we have to date. It's a mission specifically designed to gather data about the lunar environment, which will be very valuable to us."

In addition to NASA's studies, 14 companies have signed up to compete in the Google Lunar X Prize, an international competition challenging private companies to develop a robot that can safely land on the moon, travel 500 meters over the lunar surface and send images and data back to Earth.

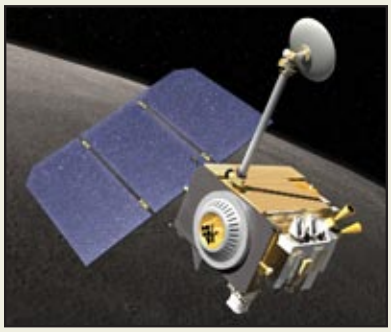
After the various findings are studied, the development window will be narrowed to the more practical aspects of lunar habitation.

Considering the basics

For now, though, the sky's the limit as far as conceptualizing the structure that will sustain human life on the moon is concerned.

"We're in the idea stage," Culbert reiterated. "Our job is to come up with lots of ideas and lots of scenarios. You put all these ideas out there and then wait and see where the discussion with partners and the political process takes us."

Even with the ability to generate limitless ideas, there are certain constant requirements to consider, regardless of the final plans for the structure. Namely: mobility, habitation, communication, power, safety and efficiency.



An artist's rendering of the lunar Reconnaissance Orbiter.

Location, location, location

As the different variables and challenges of living on the moon are weighed, one of the most obvious questions is where do you build? With the Apollo moon landings, the equatorial areas of the lunar surface were chosen for ease of landing. Those stays on the moon's surface were relatively short in comparison to what Constellation is planning. Therefore, availability of light was not an issue.

... the polar regions - which spend 80 to 90 percent of the time in the sunlight - are more habitable than other areas.

This time around, however, the availability of light is a primary concern. Some of the outpost's energy will most likely come from the sun. That's one reason the polar regions – which spend 80 to 90 percent of the time in the sunlight – are more habitable than other areas.

Of course, the data collected by the LRO will give the team more information with which to make their outpost location determination.

The dust dilemma

Though the Apollo astronauts didn't stay on the moon long enough for it to become a serious issue, their experiences with lunar dust put it near the top of the list of concerns for today's team. The lunar surface is blanketed with a thick layer of the fine particulate, and it sticks to everything it comes into contact with.

"We plan to stay long enough this time that we will need to deal with the dust in a more effective way," Culbert said.

Kent Joosten, Constellation's deputy chief architect, compared the lunar soil to broken glass.

"It's very abrasive," he said. "It doesn't move on it's own, but when it gets somewhere ... it's going to do bad things."

In an effort to avoid those bad things, engineers are carefully considering every area of the lunar outpost that would be exposed to the dust. According to Culbert, they have to consider the effect of lunar dust on all the equipment and structures they plan to place on the moon — everything from the wheels on rovers to the habitats in which people will live. Engineers are looking into ways to protect bearings, seals and electrical components to fuel so that dust doesn't affect them, yet they can still be maintained.

The dust not only causes mechanical issues, but health concerns as well.

Unlike typical Earth dust, lunar dust has been bombarded over millions and billions of years by meteorites, solar winds and other hostile galactic phenomena, which have given the particulate its shape and abrasive properties.

One of the early solutions to the dust problem is the development of suit ports. During the Apollo missions, astronauts put their suits on and took them off inside the LEM. Consequently, all of the dust on their suits came back inside with them. The lunar architecture team is exploring the idea of leaving the suits, along with the harmful dust, outside. Astronauts can climb into the suits through a suit port and only bring suits inside the habitation for maintenance.

Radiation

Of the many considerations involved in the early stages of developing lunar architecture, how to protect against high levels of radiation present on the moon is among the most important. Without an atmosphere to protect them, those on the moon's surface are left exposed to extreme levels of radiation resulting from massive amounts of protons and electrons produced by the sun.

"The hard thing about radiation is we don't know how bad it is," Joosten said.

> **"The hard thing about radiation is we don't know how bad it is."**

On Earth, and even in low Earth orbit, radiation is not something that warrants much consideration. When humans start venturing further into space, that changes.

"Most people don't understand it very well," Culbert said. "Radiation is not something we deal with on Earth very much. Our atmosphere and the Earth's environment protect us from that, and when we start putting people outside of those environments, outside of the atmosphere, you have to ask: How do we protect humans from those things? And how much exposure is okay?"

Apollo-era data on the effects of radiation is limited to short-term exposure. Longitudinal studies are conducted annually on all astronauts, so the long-term effects of human space flight, including time spent in lunar environments, is monitored. While there have been no causes for alarm, the amount of radiation exposure experienced by astronauts is always a concern.

Studies are currently under way to determine the best method of protection against the radiation. In this, there are two types of exposure to be addressed: There is the constant amount of radiation present known as background radiation; and then there is the more dangerous radiation caused by cosmic events such as sun flares and coronal mass ejections. Researchers are conceptualizing several options to protect against both types, but much like the rest of lunar architecture, these studies are still in the early phases.

Thermal Conditions

Like those of deserts on Earth, temperatures on the moon fluctuate drastically depending on the presence or absence of sunlight, and any habitat designed for the lunar surface will have to accommodate the swings.

"Thermal management is likely to be an interesting discussion and may require a different approach than what we use today," Culbert said.

In low Earth orbit, temperature management is relatively easy to handle due to exact periods of light and dark. On the lunar surface, this isn't the case. At the polar regions of the moon, the surface systems and those inhabiting them will experience extended periods of darkness. The duration of these dark periods will change based upon location and terrain features.

"Right now, almost all our thermal systems are on a well-defined schedule," Culbert said. "The space station goes around the Earth, in and out of the sun on a well-defined schedule. Same thing for the Apollo crews. We may face some interesting thermal conditions that we'll have to design systems to handle."

Realizing a dream

The only thing greater than the challenges faced is the desire of the team to overcome them. For many in and around the agency, the moon landings of Apollo were the inspiration of a career in space and served as the overture of their lives' work. Being a part of going back is the completion of a dream 40 years in the making.

"When I was a little kid, I got to see the people land on the moon. That was pretty exciting stuff," Culbert said. "And to think that we get to be the guys who get to do it again ... that's cool."

Shuttle Artifacts

What should be preserved for posterity?

To find out about the challenge of preserving shuttle artifacts, *Rendezvous* interviewed several people who are deeply involved in the complexities of Space Shuttle Program hardware, equipment and facilities. Rich Wickman, transition manager for Infrastructure, and Lindy Fortenberry, shuttle program artifacts lead, are working to define the scope of shuttle artifacts and help the program get its arms around the enormity of this task. To learn what the challenge looks like from the perspective of the people who will ultimately preserve and display shuttle artifacts, *Rendezvous* also talked to Valerie Neal, curator of the shuttle collection at the National Air and Space Museum of the Smithsonian Institution in Washington, D.C.

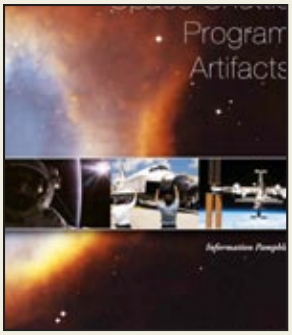
What's an artifact and who decides?

Normally, we think of artifacts as objects from bygone eras that give us a window into what life was like in the past. We think of crumbling ruins, dusty relics from ancient tombs, shards of pottery and yellowed leaves of parchment. But what is an artifact, exactly? And who decides what's an artifact or not?

To NASA and the institutions interested in preserving the legacy of the Space Shuttle Program, artifacts are the items that best capture the human or technological achievements of the United States human spaceflight program. They are things that teach and inspire. And they are the "firsts."

… artifacts are the items that best capture the human or technological achievements of the U.S. human spaceflight program.

The task of figuring out what should be considered an artifact is shared by a large team of people from NASA's Office of Infrastructure, the Office of Public Affairs, the Space Shuttle Program and center institutional offices, plus representatives from almost all the aspects of program logistics and flight operations. And it's also the people — educators, historians and visionaries from the nation's top air and space museums — who care about preserving the legacy of our spacefaring achievements so it can be presented to a wide-eyed audience.



Addressing the interest in artifacts

In 2008, an informational pamphlet titled "Space Shuttle Program Artifacts" was made available by NASA to help answer key questions and map out next steps for institutions interested in acquiring shuttle artifacts. In it, NASA defined the term "Space Shuttle-Related Artifact" as "those items having significance to the history of human spaceflight in the space shuttle era."

In late 2008, NASA issued a formal Request for Information – or RFI – to obtain input from "educational institutions, science museums and other appropriate organizations with experience in public display of space hardware and nationally recognized historical artifacts." In addition to determining which entities could bear the cost, including preparation, transportation and the provision of an appropriate venue for display, the RFI sought to establish how these artifacts could best be used to inspire American students and the public at large.

From Wickman and Fortenberry's perspective, the challenge often seems daunting. There are, after all, more than 1.2 million line items to be excessed, including the elephants-in-the-room: the orbiters and their main engines (flown and not flown). In fact, of those 1.2 million items it was those few iconic items that made the RFI necessary.

Rich Wickerman, transition manager for Infrastructure

Lindy Fortenberry, shuttle program artifacts lead

Finding a home for retirement

"In the August timeframe, we were getting a better handle on the transition and retirement budget," Wickman said. "It became clear that the budget would not allow NASA to bear the cost of preparing three orbiters for public display. So the thought was put on the table that we should use the RFI as an opportunity to see what organizations out there might be able to help offset the costs of transferring an orbiter to their organization."

Unfortunately, by the time it made it into the news, offsetting the costs had been translated by reporters as putting the shuttle on the auction block – something NASA has no intention of doing.

"We're not selling the shuttle," Wickman explained. "We intend to donate them to eligible organizations. But we will be asking those organizations to pick up the cost of moving the orbiters and making them safe for public display."

… the orbiters are $2 billion machines, so selling them for what they are worth would be pretty hard to do.

Wickman went on to make the point that the orbiters are $2 billion machines, so selling them for what they are worth would be pretty hard to do. Not to mention the fact that, since all NASA property belongs to the United States taxpayer, NASA must follow federal property disposal regulations, which allow eligible organizations to request that property be donated to them before it is offered for public sale.

And though they may seem a bargain compared to the price of a shuttle, the costs for safing and moving the orbiters are significant. Wickman offered a rough estimate of $42 million dollars per orbiter, which would include about $6 million in ferrying cost with the remainder divvied up among safing operations and preparations for display.

The devil is in the details

Aside from the logistics of acquiring, transporting and displaying major orbiter and main engine components, Fortenberry said the real devil will be in the details of determining what is an artifact and identifying its constituent parts — all its bits and pieces, in other words. She underscored the point that the 1.2 million line items that make up the space transportation system are all listed as piece parts. In some cases hundreds of these line items will come together to comprise a more complex artifact. There will also be smaller, less complex items identified as artifacts that may be single line items of property. Although the actual number of space shuttle artifacts has yet to be determined, it will surely number in the thousands.

Criteria and collections categories

While she and Wickman are focused on the complex logistics of offering and readying shuttle artifacts to the appropriate organizations, Valerie Neal and her colleagues are making sure that the items requested by the National Air and Space Museum are meaningful to the American public and add to the depth and completeness of the national collection. As she explained, the Smithsonian doesn't just "get" artifacts. There's a complex set of criteria that guide decisions about acquisitions for their collections.

Dr. Valerie Neal, curator
NASM Smithsonian

"We look at our collections in terms of fundamental history, so we are always looking for artifacts that are related to major milestones in the history of aviation and spaceflight, or represent the people who made significant contributions to the era," explained Neal. "Historical significance is our primary criterion: What did this object or person do? Did it create a significant advance in the science and technology of spaceflight? Did it make or change history?"

However, fully understanding the collections criteria at the National Air and Space Museum is a little like peeling an onion. There are categories and subcategories, or layers upon layers, of collections. Neal describes it as a 'hierarchy,' similar to biological classification of genus and species.

"Our collection categories include spacecraft, spacecraft parts or components, spacesuits, engines, electronics, guidance navigation and control devices, crew equipment and scientific equipment," Neal listed. "And then each of those categories is further broken down into specific types of things, such as cameras and tools within the crew equipment category."

Then there are categories of significance and themes within the collections.

"Our highest priority is a flown artifact."

"Our highest priority is a flown artifact," Neal stated. "If not flown, then a backup. If not a backup, then a test vehicle. And if not a test vehicle, then an engineering model. But we try to stay as close to the actual flown artifact as possible."

"One of our themes is 'technological innovation and change,' which focuses on the inventions and the advances that mark genuine turning points in the history of flight (and spaceflight) technology," Neal said. "Other themes include social or political influence, such as 'what are the motives for flight and what are the consequences?' and war and national security, of course. The individuals and groups who have shaped aerospace history, such as the visionaries and the people who pushed the envelope, as well as the behind the scenes people who really made the space program happen – they all have a place in our collection."

The Enterprise on display at the Udvar-Hazy Center of the National Air and Space Museum in Washington, D.C.

So when the matrix of basic historical significance or technological collecting categories and intellectual themes comes together, that's when they know they want to pursue an artifact.

Not quite collectible. Yet.

Currently, the museum's spaceflight collection doesn't include much that represents the shuttle era, because not much has been excessed from the program yet. The space transportation system was designed as a reusable system in which components, such as orbiters, solid rocket boosters and other hardware, were used over and over again. However, the current collection, such as it is, has had a crown jewel on display since 1985 and on display since 2003— the Enterprise test vehicle.

Neal and her collections staff are working to develop their shopping list of shuttle artifacts (approximately 250 objects, including a 'flown' orbiter) that they hope to snare for the museum's collection. Thanks to a "Public Display and Outreach Wish List" collected by Wickman's organization at NASA Headquarters with input from all NASA centers' public affairs offices, the NASM, the Space and Rocket Center in Huntsville, Ala., and the National Museum of the U.S. Air Force in Dayton, Ohio, many items that will be of interest as artifacts have been identified.

Advance planning

Wickman and his colleague, Diana Hoyt, have also been working to establish a Space Act Agreement with the American Association of Museums to bring in a more universal perspective on how artifacts are viewed, what is important to preserve, and how judgments are made as to where they should end up. This kind of careful consideration of a program's legacy simply didn't happen in the years following the Mercury, Gemini and Apollo programs.

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"We're trying to avoid that by doing this planning up front, and also by partnering with interested parties so that NASA doesn't bear the full burden," Wickman explained.

The importance of preserving shuttle legacy is certainly not lost on him. He emphasizes that much of the knowledge and passion invested in the Space Shuttle Program resides in the program's workforce. He thinks 'shuttle folks' should be tapped to help determine what items are potential shuttle artifacts and what are not.

"I grew up with Mercury, Gemini and Apollo," Wickman reflected. "All were programs done in rapid succession and just a few years in duration. But the shuttle program has flown for more than 25 years and for more than 100 missions. It's probably the only American spacecraft that a whole generation knows."

So Wickman would like to preserve an understanding of the full capability of the machine, of the entire system and what it was able to achieve over its operational life.

"It is quite an impressive record," he said. "You're talking military and non-military missions, science missions, construction of the International Space Station, the deployment and repairs of the Hubble Space Telescope, and the luminaries who have flown aboard our space shuttle."

But speaking as an engineer, he marvels at the space shuttle as the first and only reusable space vehicle that was designed and built to be launched into space, return to Earth and land like an airplane.

"That's a story right there," Wickman concluded.

Looking past Wheels Stop

A typical day in the MER during STS-121. The S&MS consoles are located out of frame to the right.

Doug McMullen: Man with a plan.

All his life, Doug McMullen has had a productive habit of looking at the end objective and then working backward.

It's served the SAIC Operations, Integration and Risk Manager well over the years. And now, with less than 18 months left before shuttle retirement, he's using his habit to develop career-sustaining strategies for his Safety & Mission Assurance team. To McMullen, "transition" is not a future eventuality. It's now. And he's been thinking about it, preparing his team for it and, true to form, working it backward.

Backtracking to find his way

Life in Oklahoma, Circa 1969.

As an impressionable 9-year-old Army brat living in Oklahoma, McMullen decided that he was destined for a career in the space program after watching Neil Armstrong walk on the moon back in 1969. But how to become an astronaut? He worked it backward.

Back in the seventies, before NASA began recruiting scientists and mission specialists for the shuttle program, he reasoned that the one thing most astronauts had in common was that they were pilots. So after his father retired from active duty and moved the family to Houston, McMullen put his plan in motion. First he completed high school in South Houston and earned his Bachelor of Science degree in Electronic Technology from the University of Houston. Then he earned his commission as an Officer in the U.S. Navy.

"I backtracked it," McMullen explained. "I said, okay, to become an astronaut, you have to be a test pilot. To be a test pilot, you have to be in the military and be an officer. To be an officer, you need a four-year degree. I looked at my objective and worked the equation backward until I determined the path I needed to take and all the steps along the way."

But even the best laid plans sometimes go awry. He tried to become a pilot in the navy. However, less than 20-20 vision in his right eye prevented that. Instead, he pursued the navigator route thinking that he might be able to transition over into becoming a pilot... to no avail. So instead, he decided to direct his ambition to test pilot school for navigators.

"But that didn't happen either," he remembered. "All those cards that needed to fall into place to become an astronaut candidate just didn't line up."

Does he regret it? Not a bit. McMullen was a navigator in the navy for reconnaissance aircraft, which meant he flew all over the Pacific theatre. He visited lots of different countries and remembers that it was an exciting time in his life. But he never once gave up on his dream to work in the space program.

Left: At officer "Boot camp" in Pensacola, Fla., 1984.
Right: Just prior to getting out in 1990, in front of his mission aircraft.

Determined and driven

McMullen (right) and STS-47 payload specialist, Mamoru Mohri (left) in an Orbiter Processing at KSC in 1992.

"I got out in 1990, about the time the Berlin Wall was coming down and the Cold War was wrapping up," McMullen remembered. "The first thing I did was buy a suit, update my résumé and hit every NASA contractor I could identify. I had made my mind up that I was going to work in the space program... I just didn't know what kind of work it would be."

Turns out it wasn't exactly what he'd dreamed of, but it was close. He started out with United Space Alliance, as an instructor for NASA's Space Flight Training Division. From 1990 to 1996, he worked as an instructor to the astronaut corps, first in communications and later in guidance and navigation. Looking back today, he smiles at his initial reaction to the job offer.

"I didn't even know there was an astronaut training program," he said. "I thought these guys were all geniuses who trained themselves!"

So he became a member of the team that was responsible for teaching the astronauts how to fly the space shuttle and, to this day, considers that instructor job one of his favorite in his 18 years in the space program. But at the same time, McMullen earned his commercial and multi-engineering pilot's license, and completed his Master's degree as well. So much for complacency.

Exploring his career potential across the pond

From 1996 to 2004, McMullen worked for GHG Corporation as Senior Engineer-Safety & Mission Assurance for both the International Space Station and the space shuttle. In the middle of that stretch, he jumped on the opportunity to help design a foundational astronaut training program for the European Space Agency. From 1998 through 1999, he worked for H.E. Space Operations, BVD, in the Netherlands, conducting needs analyses, defining project requirements and collaborating with international peers to implement the program. And in 2004, not long after President Bush announced the Vision for Space Exploration, he went to work for SAIC, where he is today.

McMullen in the Soyuz trainer while working as a contractor to ESA in 1998, Star City.

"As manager for shuttle operations and integration, which also includes some Constellation work, I have 39 people in my group," he explained. "The people who sit in the Mission Evaluation Room – familiarly known as the MER – and man the safety console are my people... I also have an integration group that handles vehicle integration issues and a risk management team that handles shuttle and JSC-related risk management issues."

Add in an extra smattering of people who do this and that, and, as one would assume, McMullen's task matrix is rather complicated. He has to monitor a lot of simultaneous activity. But to hear him tell it, he's just a resource manager who makes sure that his people do their jobs and complete their assignments. Of course, that's something of an understatement because McMullen also spends a lot of time thinking about the future.

Focusing on what shuttle transition really means

In addition to his group's shuttle-dedicated responsibilities, they're already working on Constellation projects such as the Orion crew exploration vehicle. He's hoping that soon they'll get the opportunity to contribute to Altair, the lunar lander, too. But for the past year or so, McMullen's been talking to his team about what shuttle transition really means. It's been in just the past few months that he's really become involved, learning more about the CEV architecture and how the spacecraft will be built.

... for the past year or so, McMullen's been talking to his team about what shuttle transition really means.

Facing up to workforce realities

"Based on that involvement, you can figure out what kind of engineering expertise will be needed and what kind of skills they'll need," McMullen said. "It became clear to me that there are some systems on the shuttle that won't be used on the new vehicle. For example, there are engineers who worked on the landing gear, ailerons and elevons, or the robotic arm on the shuttle and those items won't exist on the crew exploration vehicle. So that's what I took a look at to determine what skills and knowledge won't be needed in two years."

The other thing he looked at was his operations team, plus some of his integration folks who also work on console. He knew that all 17 people wouldn't be needed in between the end of shuttle and the beginning of CEV, considering that the hardware would need to designed, certified and then built and tested before the operations phase could begin.

McMullen figures he'll probably only need six or seven people in the operations area to take care of business as shuttle winds down and Constellation ramps up. So, following his penchant for working the issue backward, in his regular mid-year reviews he's already begun asking his people what they want to do with their careers.

A one-man employment agency

"Some of the questions I've been asking are 'Are you challenged in your current position? Can you see yourself doing something else? Are you interested in going somewhere else on the contract or within the human space flight program?'" McMullen related. "At the same time, I went to our company Web site to find out what kind of job openings we had here in Houston and in other locations, and found two positions that I thought fit the bill for two of my people."

The whole point was to transfer them over to jobs where he knew they'd be safe in the future …

So he brought them both into his office not long ago and offered up the idea that one go over to spacewalk safety and the other go over to space station. The whole point was to transfer them over to jobs where he knew they'd be safe in the future, not to send people to positions where it was likely that they'd get laid off, as they would were they to remain on his shuttle team.

Defining the coming challenges

McMullen's hoping that his proactive approach will wake some key people up.

"Everyone's talking about it, but it seems like only a few people are actually doing anything," he said.

Part of the problem, or the challenge, depending upon how you look at transition, is trying to get an accurate bead on what design concepts are moving forward, watching the contract awards carefully, and what's likely to happen with the budgets and the 111th Congress.

But to McMullen, being the kind of manager he is, the idea of sitting around and doing nothing to prepare his team for a potentially pared-down future in the space program, never really entered his mind. He admits that he doesn't know for sure what his numbers will need to be two years down the road, but helping his people continue their careers in space is definitely a priority, as is being honest about the many uncertainties his team will face.

As for his own future, McMullen hopes people will find his efforts useful.

"Our contract expires in 2011, which means that we'll be writing our new proposal for a new contract around the same time the shuttle program ends," he explained. "Hopefully, some of the things I've been doing with my team and the ideas we've come up with will be of value to the new program, such as our effort to retain shuttle knowledge that should move forward into the new vehicle."

"I'm trying to anticipate as much as I possibly can for the next couple of years … and hope I'm right."

In fact, McMullen's shuttle knowledge retention program was an initiative he started more than a year ago. His team has worked hard to document everything they do in mission control all the way down to effecting shift handovers and punching in logs. Because in five or six years, when they start those consoles back up, "there's going to be a whole bunch of new young people who aren't familiar with how it was done back in the shuttle era, much less how they did it back during Apollo," he said.

McMullen established an electronic share site where his team could put all this information about mission control operations. Some day down the road, the Orion mission control team will be able to rely on a huge archive to see how it was done in the past so they won't have to start from scratch or repeat any mistakes. His team has already started thinking about Orion training program requirements as well.

"It's like a chess game," he said. "I'm trying to anticipate as much as I possibly can for the next couple of years … and hope I'm right."

In the meantime, he'll keep on working the future formula backward.

Weighing In

Quips & Quotes

For this issue, we polled *Rendezvous* subscribers and previous participants of Focus and Brainstorm Sessions conducted at centers across the country on certain top-of-mind issues. We also sat down with a group of interested participants – civil servants and contractors alike – at Michoud Assembly Facility in New Orleans and at Langley Research Center in Hampton, Va.

If you'd like to weigh in with your two cents, or you have questions you'd like to ask your colleagues, the *Rendezvous* readership, please feel free to use the feedback buttons. Your responses, if used in subsequent issues of *Rendezvous*, will be kept anonymous. And if you'd like to participate in future polls, be sure to subscribe. We'll also send you notices when we update the *Rendezvous* Web site, biweekly.

- Are you getting the information you need to help you make decisions about your career in the space program? If not, what kind of information would help you most?
- How important is it for the United States to retain its leadership position in space technology and exploration?
- What will you tell your children or grandchildren about this period in the history of the United States space program?

Are you getting the information you need to help you make decisions about your career in the space program? If not, what kind of information would help you most?

Yes, I think that, from the perspective of being told all that can be told to me at this point, I have been provided with that information.
—JSC

It would benefit those of us who are not considered 'critical' to view a compilation of job opportunities in the local aerospace community and to be able to register ourselves as eligible candidates in a selection database. I would be happy to formulate this practical, friendly and realistic tool.
—JSC

Yes, I am getting all the information I need ... But, then again, my only decision is when to retire ... <grin>
—KSC

Our transition is going from a civil servant-dominated contract to a contractor-dominated one. When transition happens, there will be a cultural transition as well ... so management will need to describe a clear vision ...
—LaRC

In a word, no. I do not feel that I'm getting the relevant information I need to make appropriate career decisions. Allow me to explain: I supervise a team that provides property disposal service and oversees redistribution of excess government-owned property. Yet, since the inception of our contract here at Michoud Assembly Facility, my team and I have labored within our material sourcing group. We are not, and have not been, associated in any way with facilities. I guess you could say we are unique. I have been told that at other centers, property disposal activities are accomplished by one central group that falls under the control of the Facilities Operating Contractor. As employees who have faithfully performed an important function at our facility, my group has no idea what to expect in the near term ... For us, the future is a great unknown ... Will our many years of service be lost? Will we become employees of the new FOC and be forced to restart our careers with absolutely no seniority at the new company? Or, most frightening of all, will we find ourselves standing outside the fence, unemployed and looking back at what used to be?
—MAF

"I think we are getting as much information as the environment allows right now, and we need to be cautious – but optimistic – when planning our paths."

Yes, NASA has taken all the necessary steps to keep workers in the know ... about pretty much everything. As far as careers go, we know what we're up against, and NASA has provided options and taken care of their own.
—JSC

Not applicable to me personally since I plan to retire this summer after 43 years in the space program. For my employees, the information you are providing is very useful. It addresses both "official" and "unofficial" views and represents a good cross section of people in our business. The answer to your [question] in this period of uncertainty and poor economic news is, I don't believe anyone is getting all the information we need to truly and effectively manage our futures.
—MAF

Somebody's got to have the guts to lay out a five-year plan — even though it's going to scare people.
—LaRC

I think we are getting as much information as the environment allows right now, and we need to be cautious – but optimistic – when planning our paths.
—MSFC

How important is it for the United States to retain its leadership position in space technology and exploration?

Extremely important.
—JSC

I believe that it is absolutely crucial.
—KSC

The United States cannot afford to surrender our dominance of space. The need to explore and discover is an innate part of our nature. Denying that need is foolish and doing so would surely place us at the mercy of other nations.
—MAF

It is of the utmost importance. The United States has been the leader in space technology and exploration for more than 50 years because we had leaders who understood that the human race should always be moving forward ... not only here on Earth, but in space as well.
—JSC

"I think it's extremely important. The cost to retain our leadership will be less than the cost to regain our leadership should we fall behind. The United States would suffer the loss of technlogy during any cut back."

As to the need for the United States to retain its leadership position in space technology and exploration, and most especially human space flight, there can be no doubt. We cannot afford, as a nation, to allow our space infrastructure to decline to a point where we must rely on others for access to space ... We [would] be subject to the whim of whoever is providing the services and constantly at risk of losing access altogether. I would equate that to a self-imposed blockade to space.
—MSFC

We need to retain our leadership position for scientific and technological advancement, understanding of ourselves and our place in the cosmos, national security, to stimulate education, to maintain a strong competitive position in the world marketplace, to create high-paying jobs and to keep our place among the pantheon of great nations throughout history.
—KSC

I think it's extremely important. The cost to retain our leadership will be less than the cost to regain our leadership should we fall behind. The United States would suffer the loss of technology during any cut back.
—MAF

What will you tell your children or grandchildren about this period in the history of the United States space program?

That even under the pressures of intense schedule demands, a declining workforce, a depressed community and negative morale, we still managed to meet flight milestones, safely put astronauts in space and meet mission objectives.
—JSC

That I was part of it. That over the past 20 years, we have experienced an explosion of scientific knowledge about our near and far space environment and its effect on our planet and its habitants. That while NASA and the aerospace industry has people of all kinds — short and tall, engaged and insular, brilliant and merely smart and so on — as a group we accomplished great things. The greatest is taking those first outward-bound steps into the cosmos. And I was part of it.
—KSC

NASA at a crossroads, that's how I would describe our current period. And while the rest of the story is not yet written, I hope to be able to report that our President and NASA's leaders chose the high road and united with a common vision to travel to the moon and beyond. And, should the other path be chosen, should our leaders foolishly elect to pursue the road that leads to idleness and stagnant technology, then I will share that sad story, too.
—MAF

That this was the period of time when we decided to retain/relinquish leadership in space.
—KSC

That the United States was able to adapt to the ever-changing, worldly environment/economy and find success.
—JSC

"I was there. I was lucky to participate. It was a great feeling to believe in the mission while you earn your daily wage. Even then, we had an inkling of the larger importance of our humble endeavors."

I was there. I was lucky to participate. It was a great feeling to believe in the mission while you earn your daily wage. Even then, we had an inkling of the larger importance of our humble endeavors.
—JSC

I will tell them that we are just getting started! In their lifetimes, the knowledge of the universe and level of technology will increase exponentially.
—MAF

I have five granddaughters, and all of them are very aware and proud of the United States space programs, both manned and unmanned. I hope they grow up as I did, in a United States where we are going to the moon, launching newer and better telescopes and exploring other worlds. In a nation that appears to value short-term profit over real accomplishments that benefit mankind, that may be asking too much. I hope not. It would be a shame for my granddaughters to see only Russian, French, Indian and Chinese explorers making the next great journeys and discoveries, when all we have to do is DO IT.
—MSFC